Schottky Measurements in RHIC

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Outline

HF Schottky Hardware - 2GHz

HF Schottky Measurements

LF Schottky Hardware – 245MHz

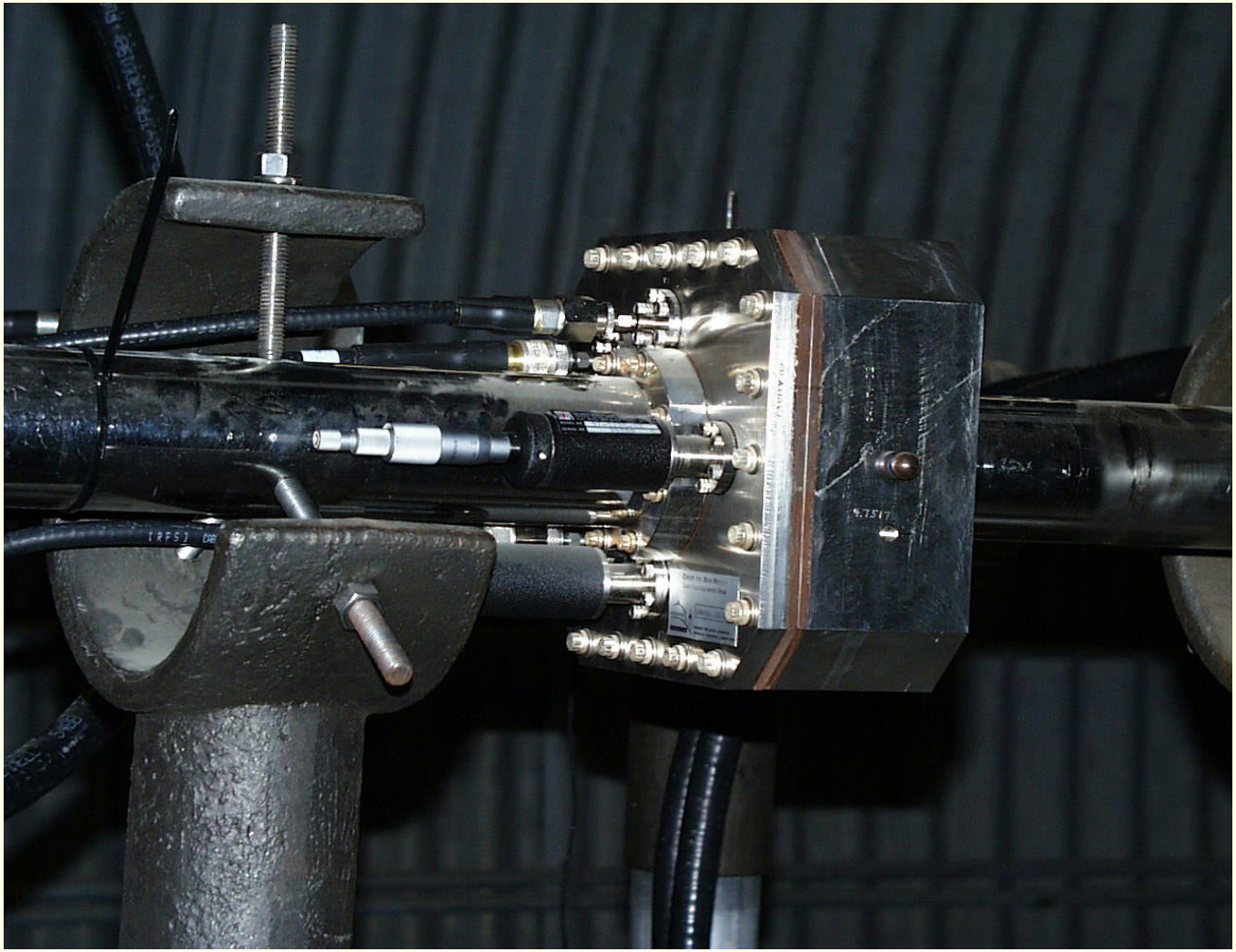
LF Schottky Measurements

Conclusions

High Frequency Schottky

- Built by LBNL - follow on to FNAL system
- Described in W Barry et al, EPAC 98 (and references therein)
- Charge is quantized, rootN fluctuations give clumps (limits)
- Gold in RHIC gives +19dB relative to protons
- Three cavity modes
  - TM210 - Horizontal 2.067GHz
  - TM120 - Vertical 2.071GHz
  - TM111 - Longitudinal - 2.721GHz
- Cavity properties
  - $Q_{loaded} \sim 5000$, Transverse impedance ~ 9 MΩ/m
- DAQ - Mix to 2MHz, examine with HP89410 FFT box

HF Schottky Cavity

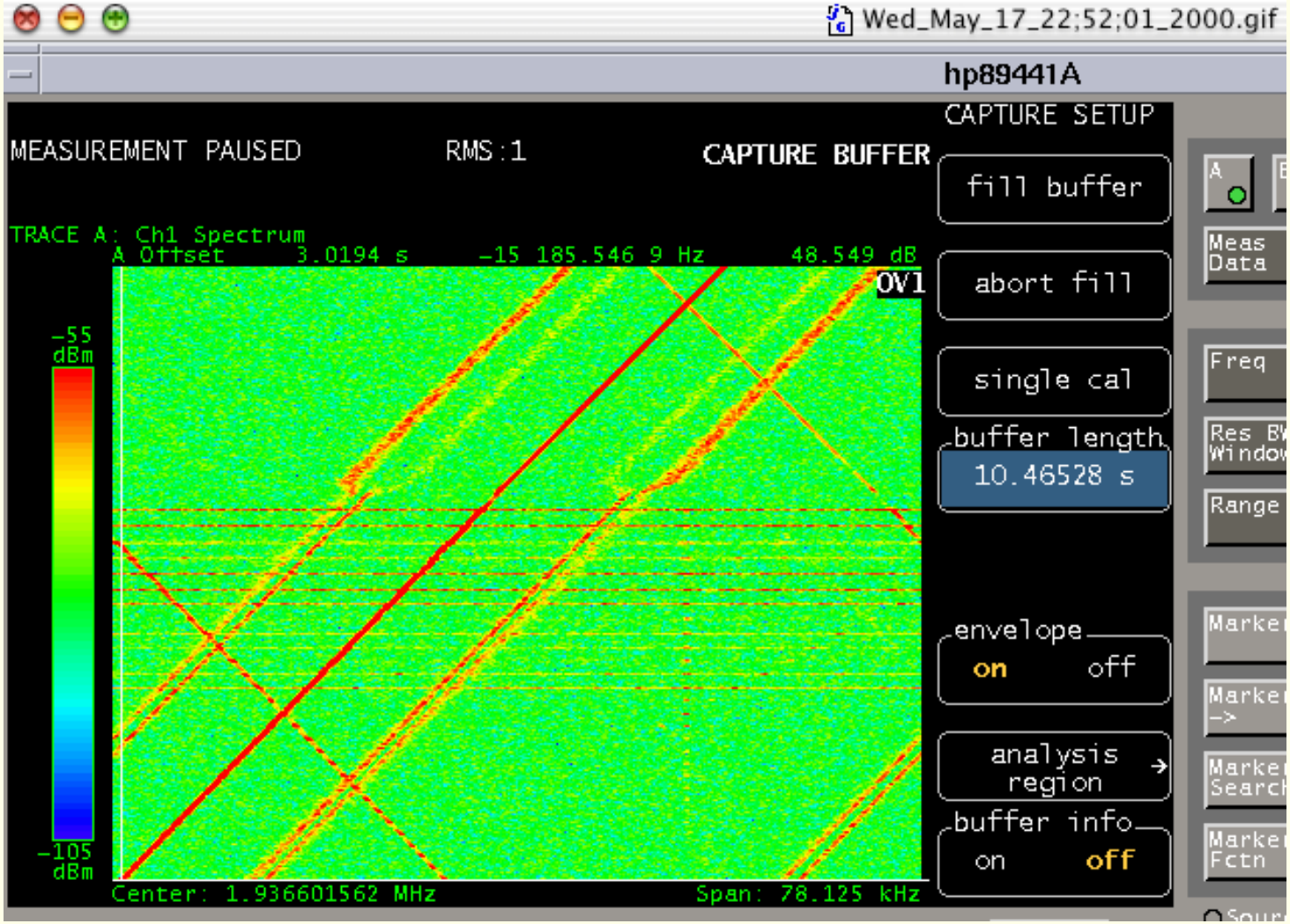


First RHIC Transition Crossing

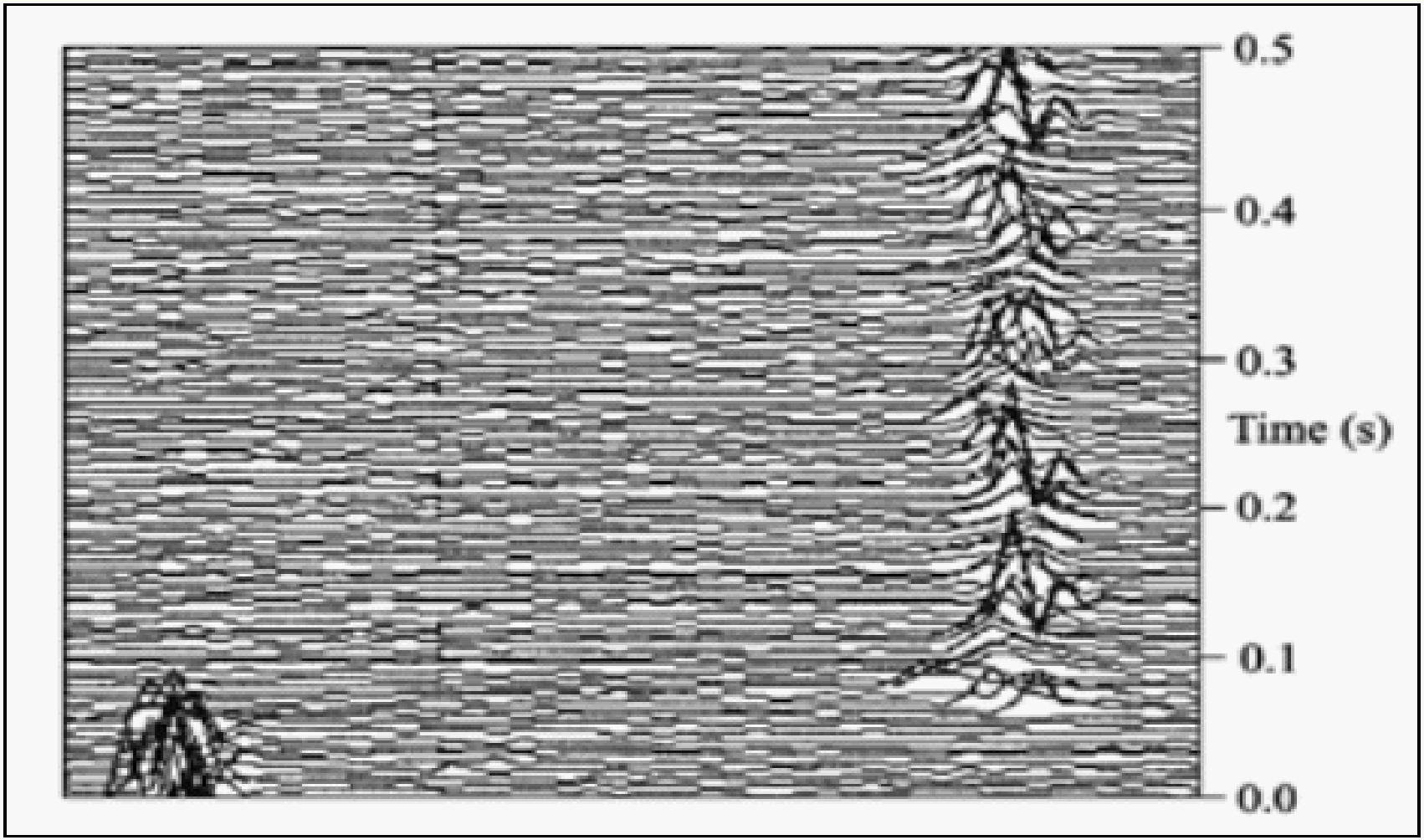
-1 sec

Transition

+2 sec



First RHIC Transition WCM

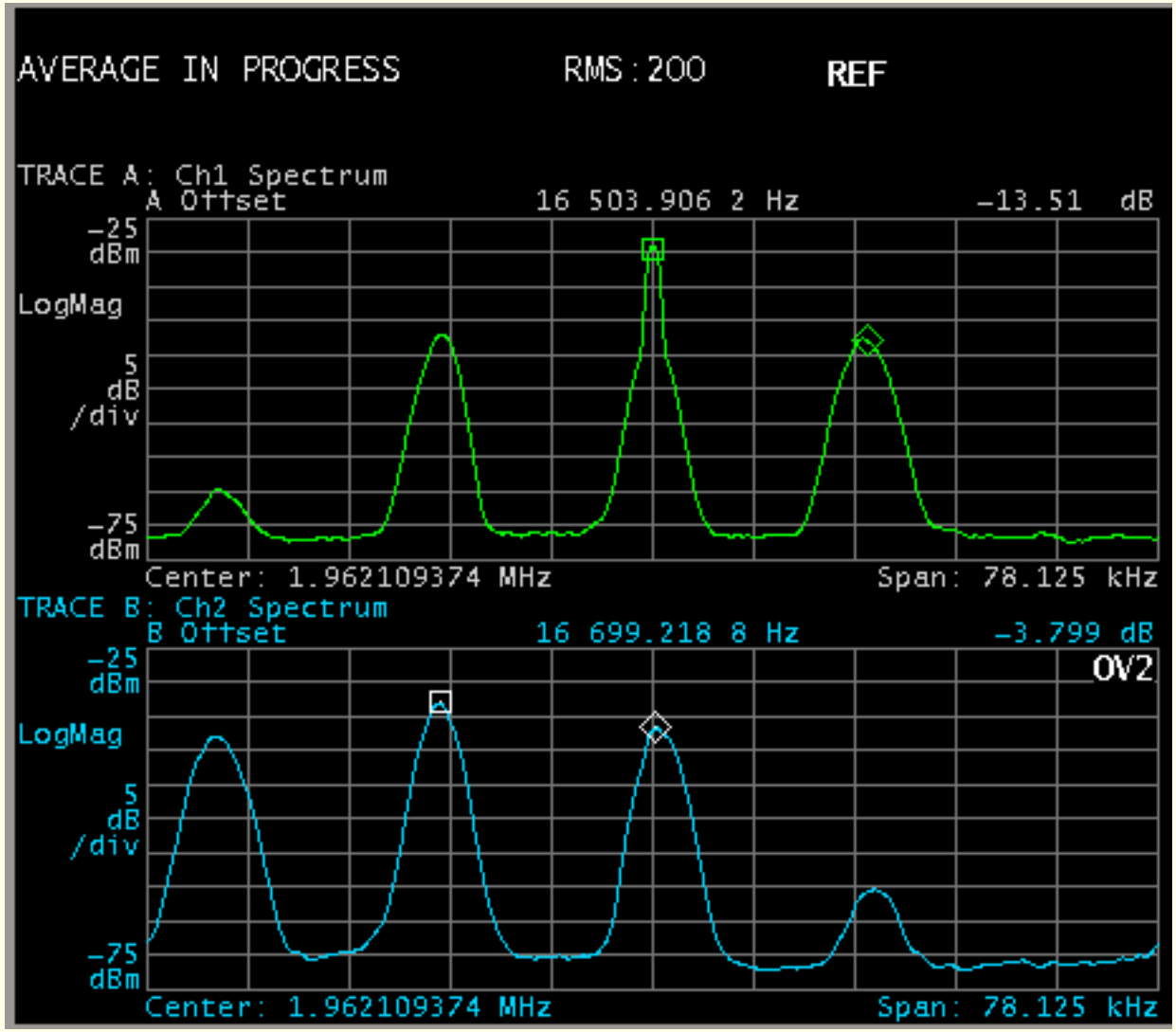


Clean Schottky Spectra

At Store,
S/N ~ 30dB

Yellow horizontal

Blue horizontal



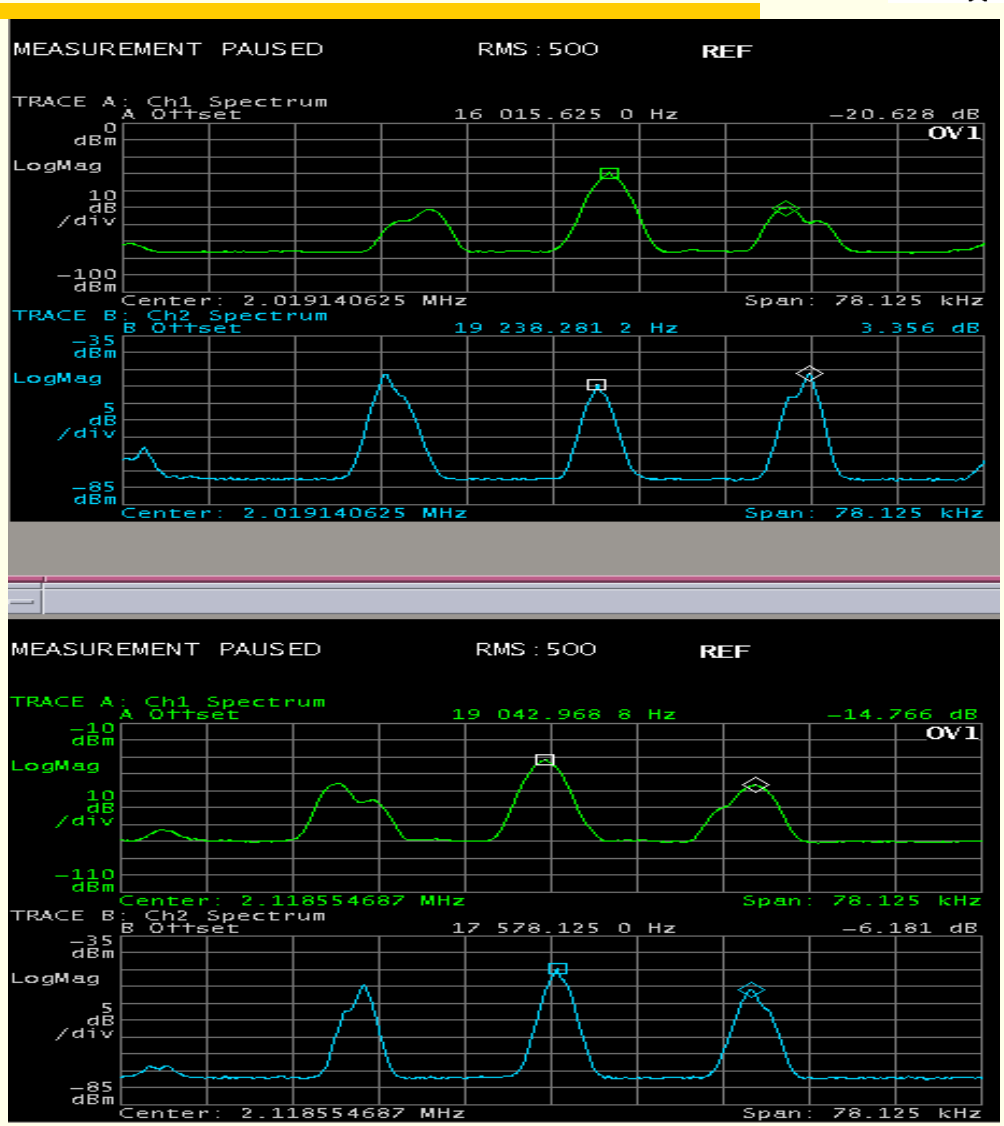
Schottky Tune Measurement

Yellow H .205

Blue H .247

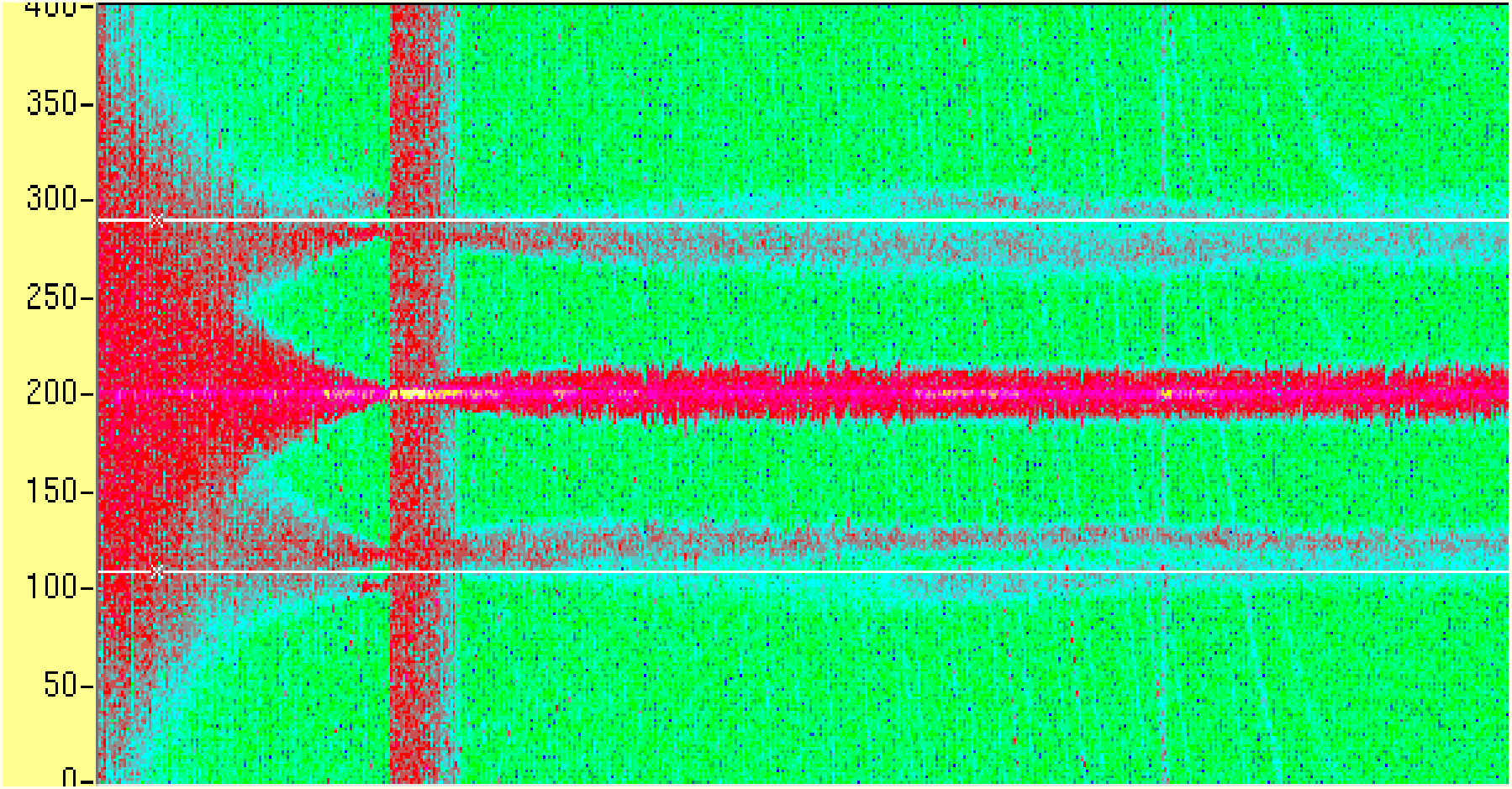
Yellow V .244

Blue V .225

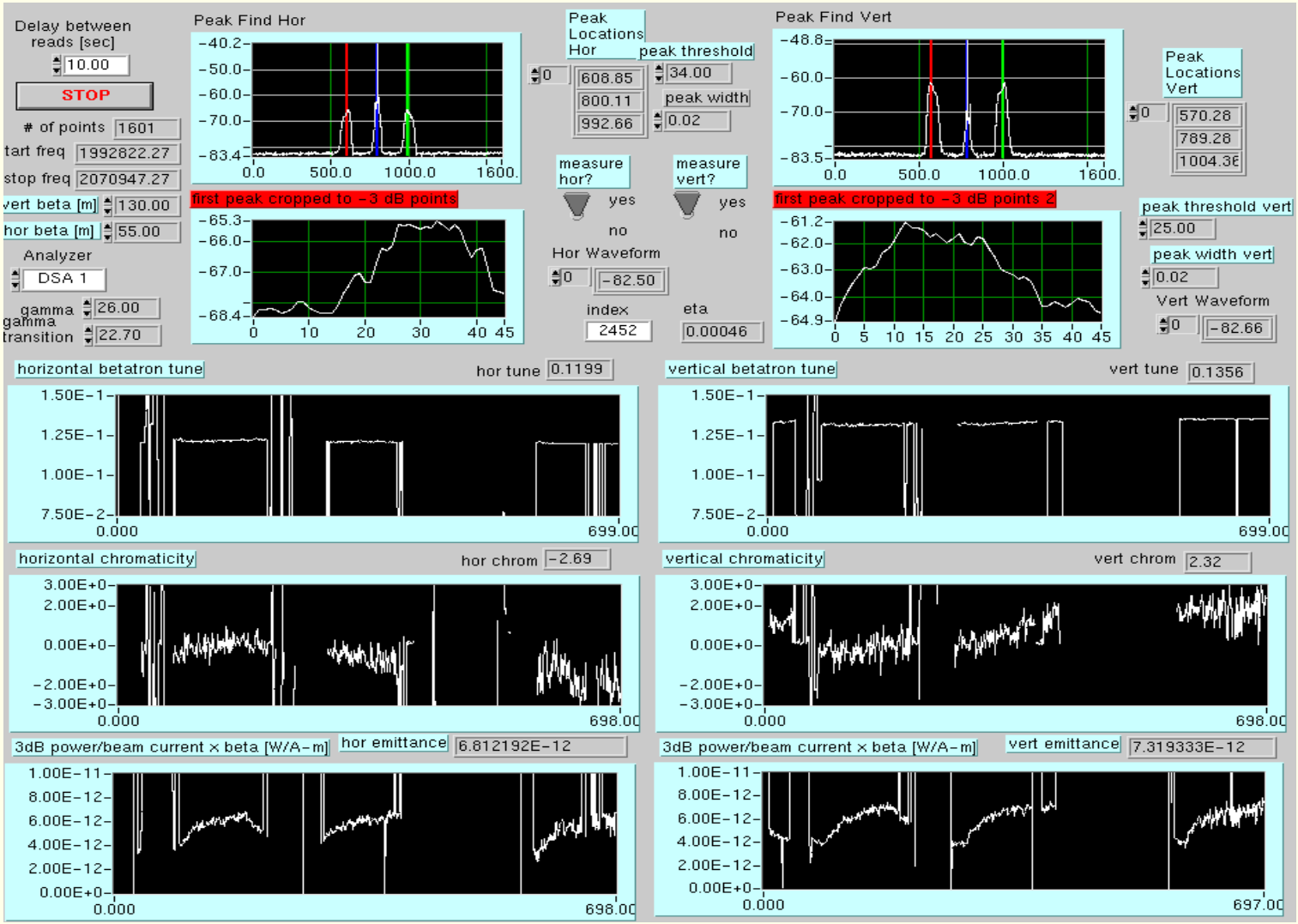


HF Schottky Tune up the Ramp

inj transition store



HF Schottky with Polarized Protons

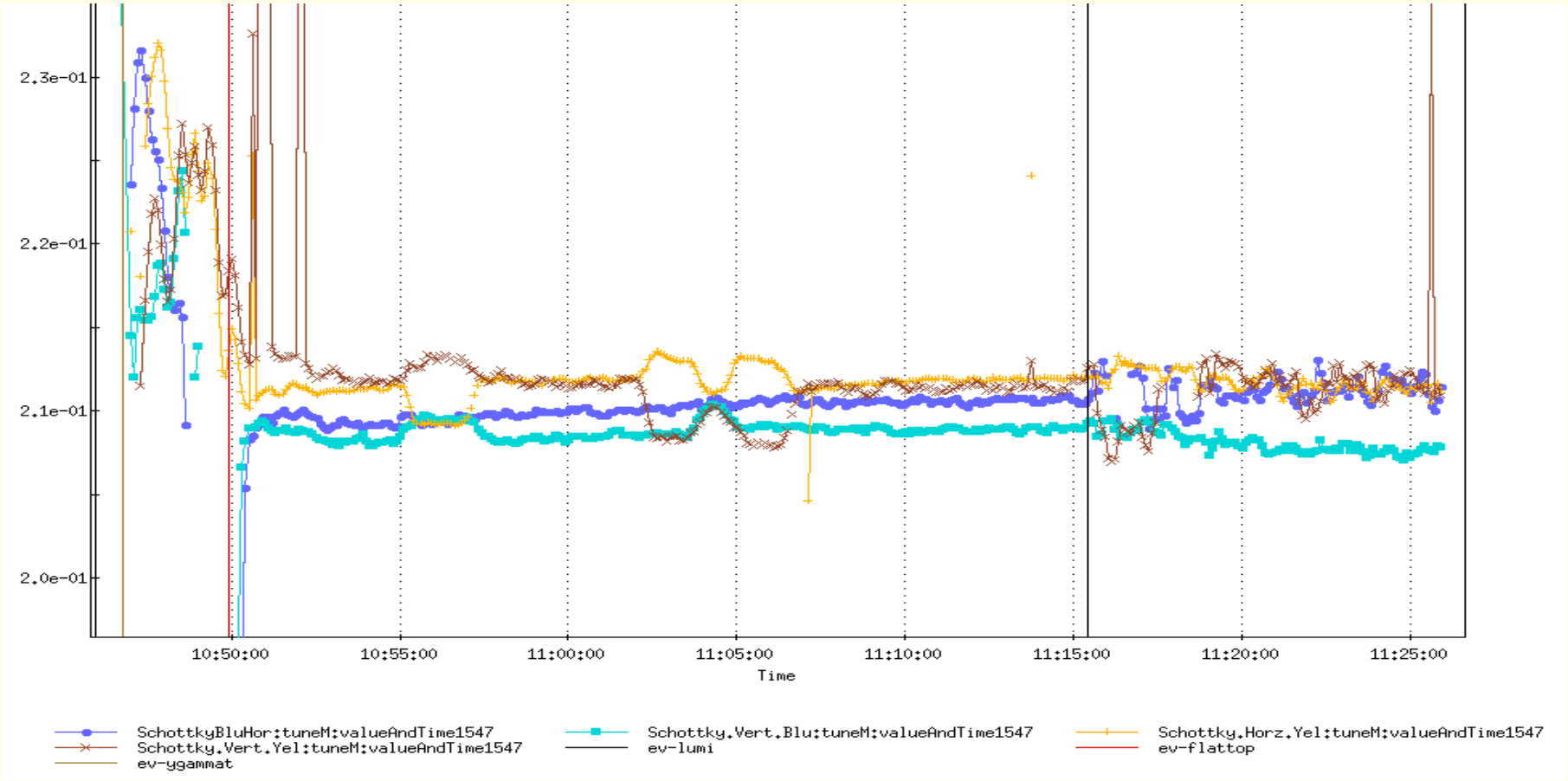


Down Ramp Chromaticity

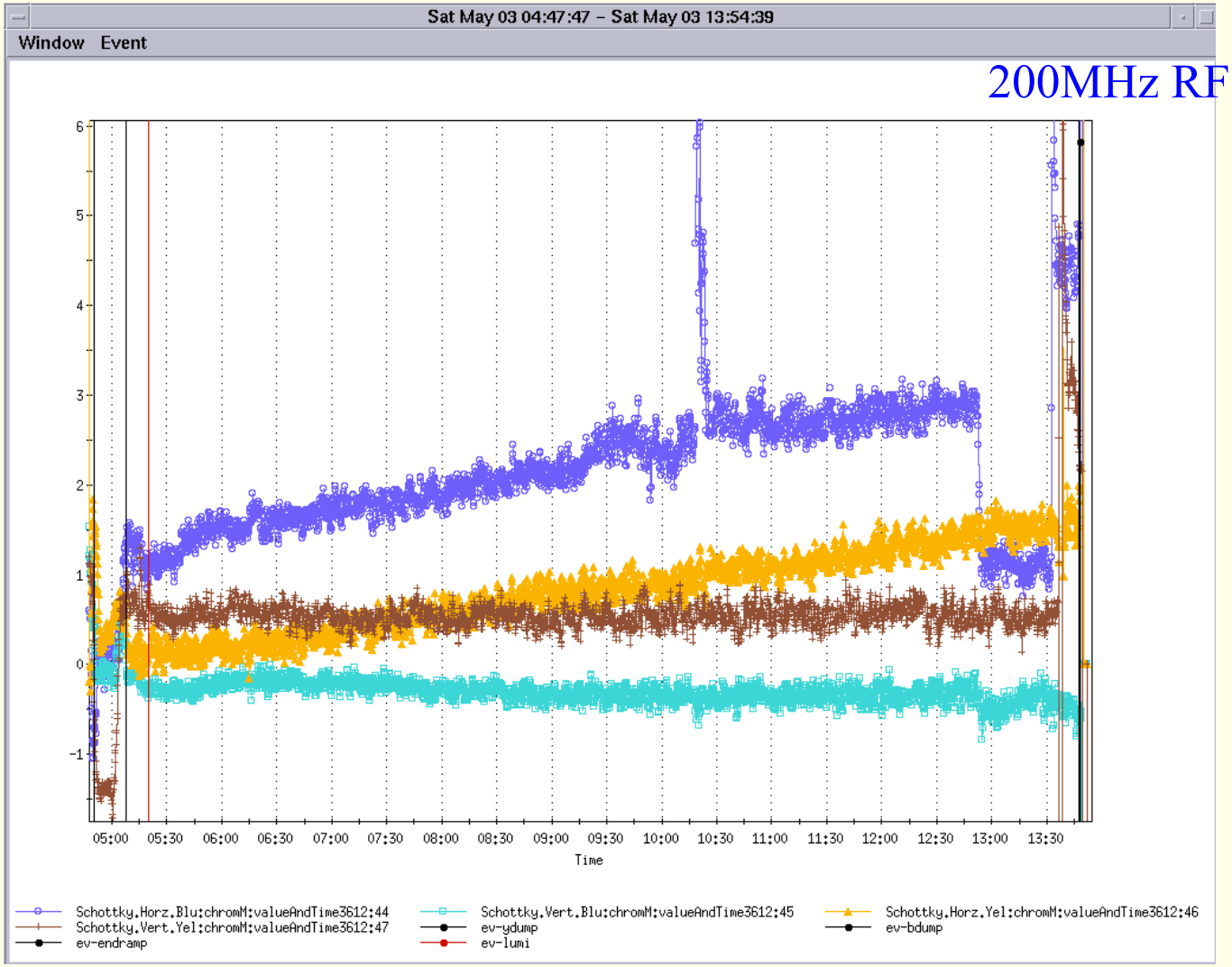
HF Schottky at Store - RHIC 2001

transition Flat top

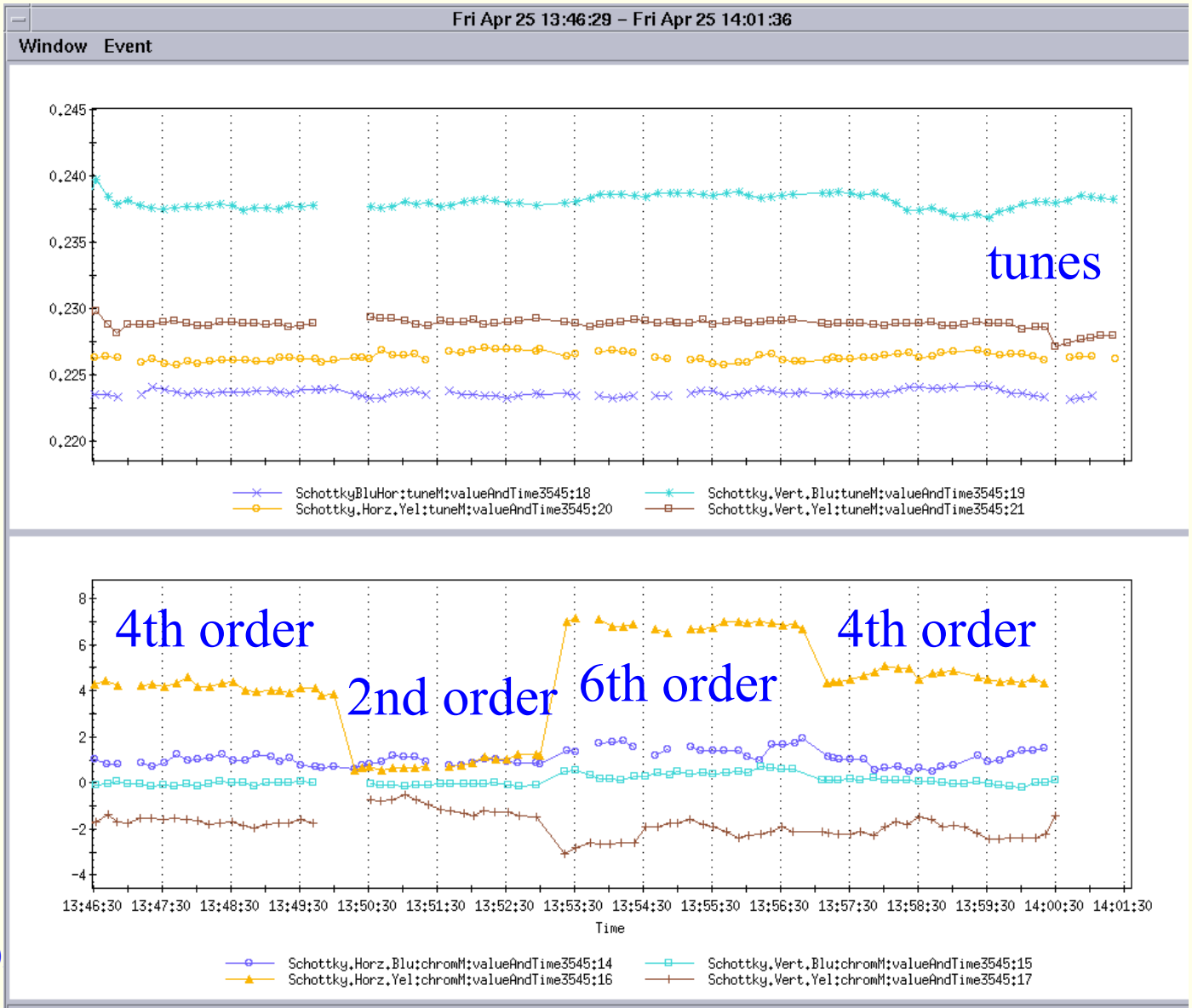
200MHz on



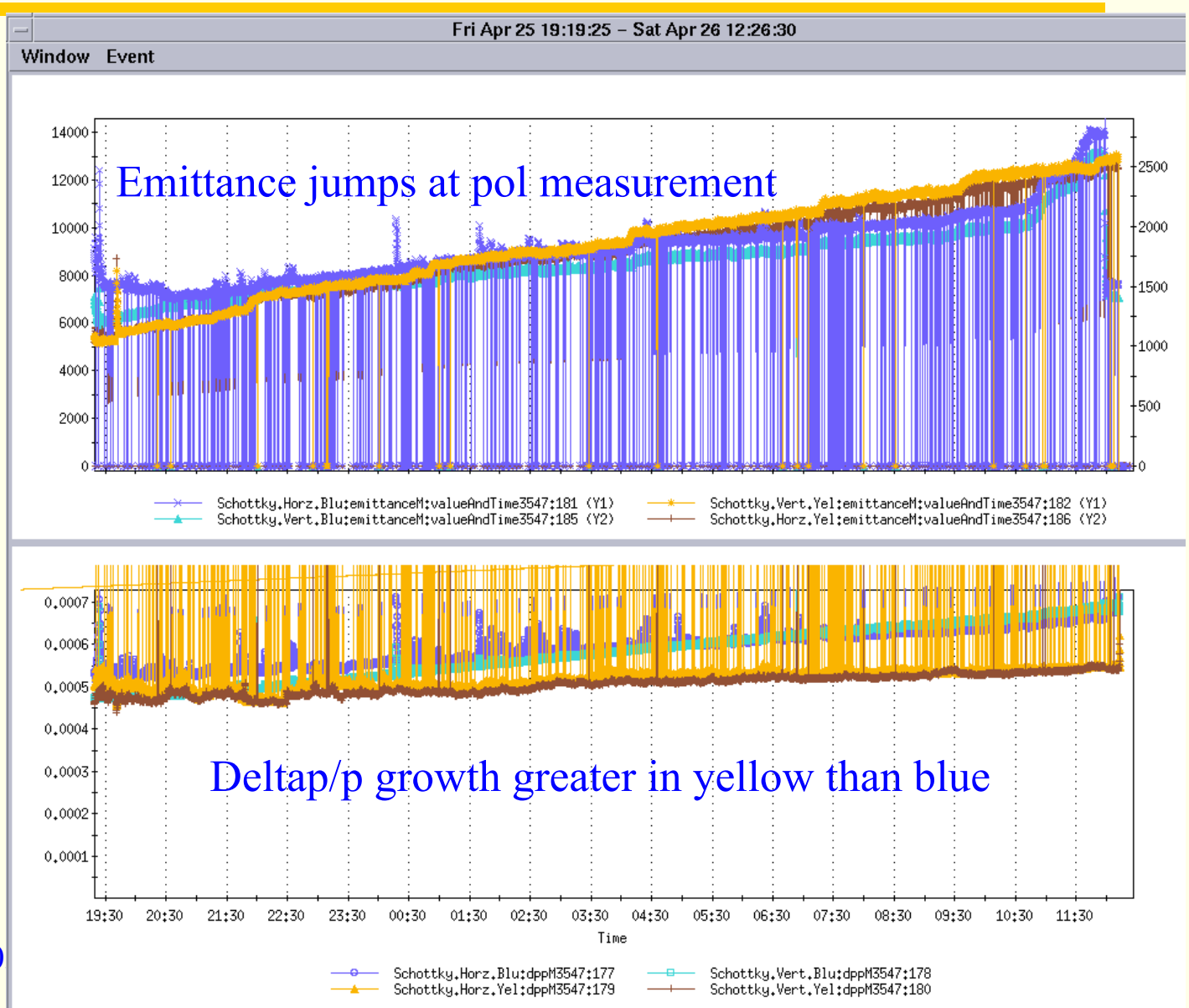
Chromaticity during Store (protons)



Fit Dependence of Chromaticity



Emittance and deltap/p thru store



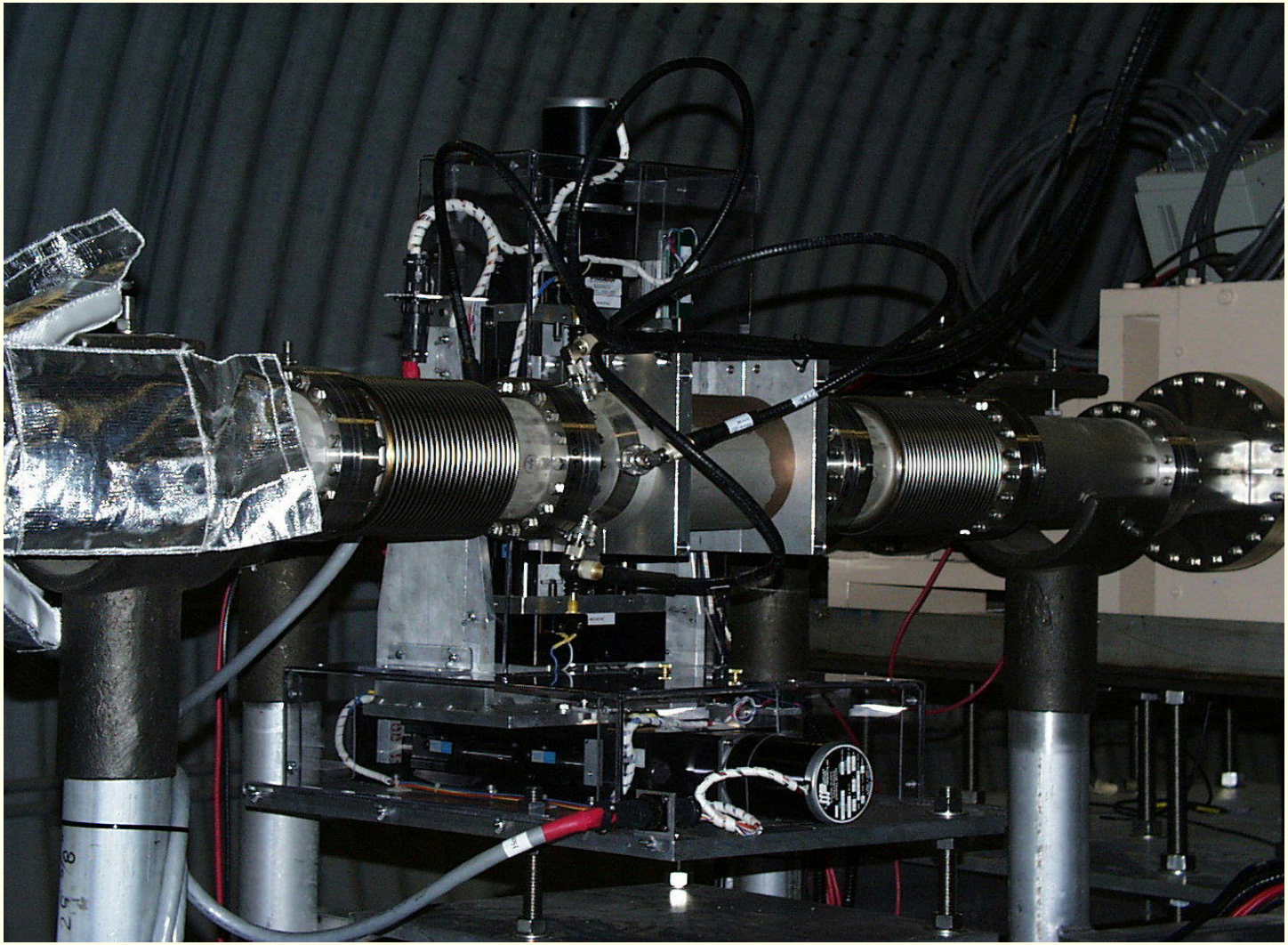
HF Schottky Lessons Learned

- Saturation - due beam steering and effect of 200MHz RF
- Coupling – affects calculated tune values
- Sensitivity to beam loss
- Mixers – out of tunnel, need separate RF synchronous LOs
- Software - Improvements to tune, chromaticity and emittance calculations
- Avoid HP DSAs - good studies tool, but poor dedicated DAQ; $$, poor data access, network storms, free for studies,...
- VME-based system, 1 DSP/FPGA per channel, TMS320C6701, averaged FFTs to control system
  - Pentek actually delivered a beta version, many problems to make this work

Resonant BPM

- M. Kesselman et al - PAC 2001
- Stub-tuned 1/4 wave resonator
- Simulated in Spice
- frequency ~ 240MHz (8.5xRF)
- Q_{loaded} ~ 100 optimal coupling
- In-tunnel hybrid for Σ and Δ
- Resonate difference mode - not sum mode signal at revolution line
- Moveable - minimize difference mode signal at revolution line
- Resonate above coherent spectrum

Moveable Resonant BPM



LF Schottky at Injection

Span 78KHz

5dB/div

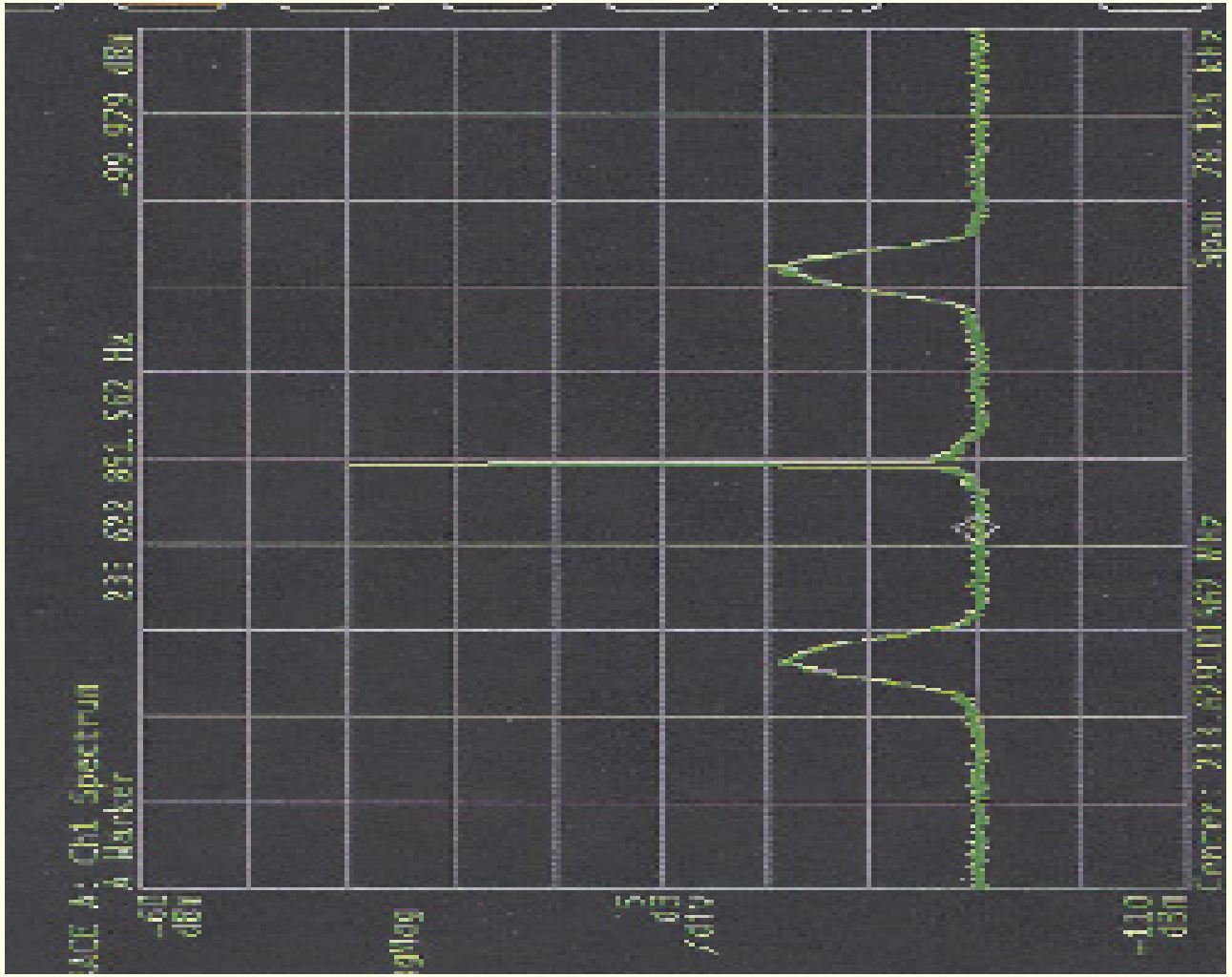
$\delta q = \eta N \delta p/p$

~ 2 KHz

$\eta \sim .007$

$N \sim 3060$

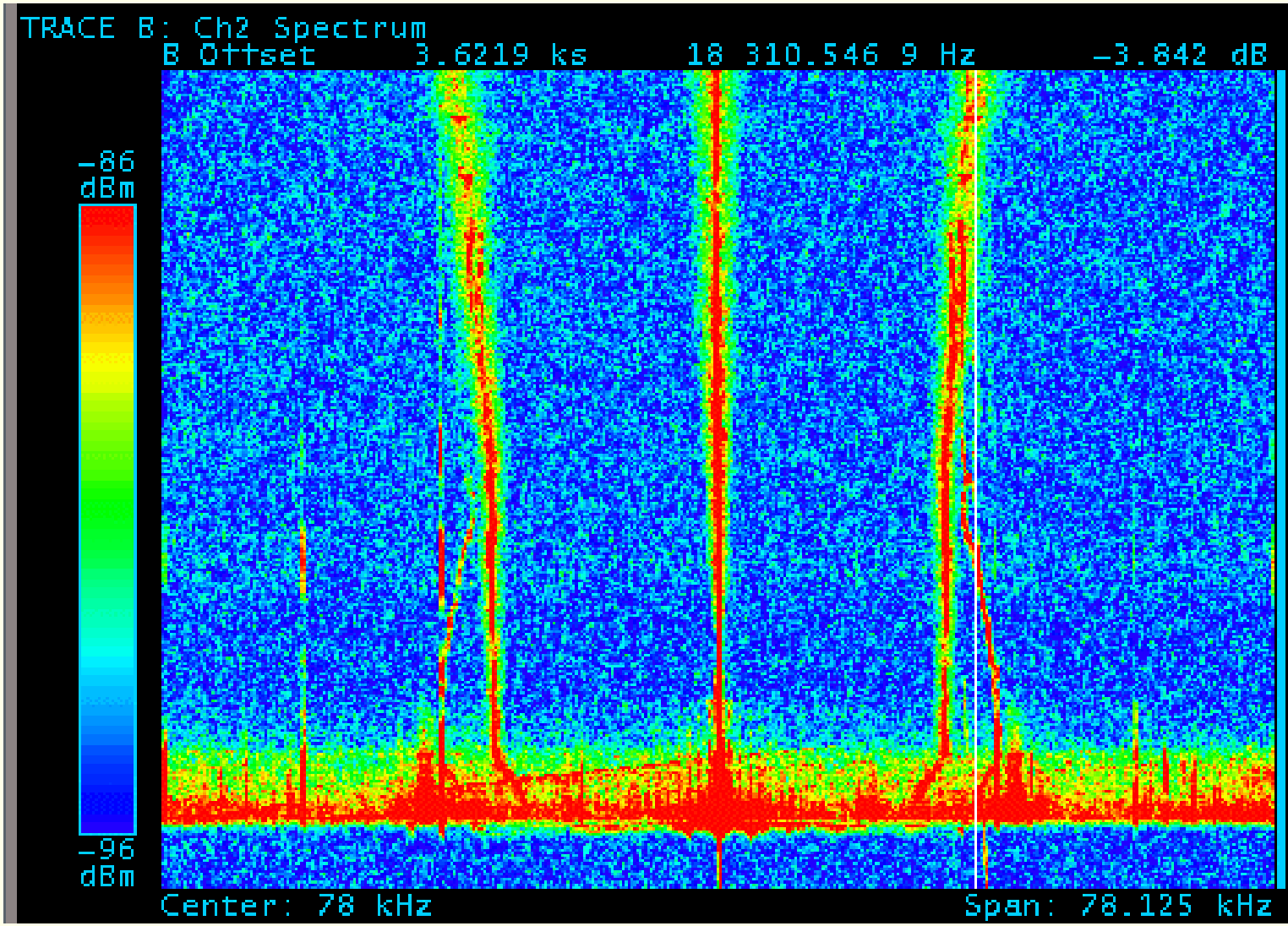
$\delta p/p \sim .001$



LF Schottky on the Ramp

Injection

Transition



LF Schottky Lessons Learned

- Saturation - due beam steering and effect of 200MHz RF
  - feedback on moveable BPM – resonant, too slow
  - mixers in tunnel, no active elements before 455KHz filter
- Sensitivity to beam loss
- Splitters and Mixers – share signal with PLL, need separate RF synchronous LOs for all blue and yellow
- Software - Improvements to chromaticity and emittance calculations
- Avoid HP DSAs - poor data access, network storms, free for studies,...
- VME-based system, 1 DSP/FPGA per channel, TMS320C6701, averaged FFTs to control system

Conclusions

- Schottky is a useful diagnostic at RHIC
- Not fully utilized by operations
  - Problems with new Pentek DAQ this run
  - Saturation and reliability
    - 200MHz RF
    - beam steering
  - Habit
- Unified Diagnostics Data Displays

Conclusions

- Many lessons learned